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CMS e-Lab

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Our project was to go through the CMS e-lab, to learn basic particle physics, and with this knowledge look at and analyze the data given to us by the CMS detector at CERN. We used different ways to graph, which included the CMS e-lab graphing UI, Many Eyes, Tableau Public, and a custom-made Matlab GUI. We learned about the Lorentz transformation and how to apply it to the data. Once every variable had a value from the perspective of the lab and parent rest frame, we could calculate other measurements such as the missing transverse energy of supposed neutrinos. From there, we came up with equations for the transverse mass of parent particles. We had wondered if we compared the rest mass of Z candidates to the transverse mass, we might be able to come up with some way of predicting the rest mass of W candidates by comparing it to its transverse mass. However, this reasoning was flawed and we could not find any dependable correlation between the rest and transverse masses. In any case, we were surprised and stumped when we saw that the transverse mass was a great percentage (mostly over 95%) of the rest mass. We had supposed that the percentage would be evenly distributed. However, we had not thought about how CMS and CERN remove data points before publishing their public data. We would hope to inquire more about how data publishing works or another explanation for this anomaly.
http://ndquarknet.wikispaces.com/Lorentz+Transformation

Astrophysics

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We are presenting results from observing the Mira-type variable star, R. Draconis, from June 20 to July 24. Our group recorded data using an 11-inch telescope and our results were a close match to the data given by other observers around the world. When we started on June 20, R. Draconis's luminosity was on the up curve in its pulsating period. Our minimum observed magnitude was 8.2 on this day (June 20), and on our last day observing (July 16) we recorded our maximum magnitude of 7.1.

Cosmic Ray Detectors

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Purpose: Our purpose is to collaborate our cosmic ray detectors (CRDs) with the CRDs at Project GRAND in Notre Dame, Indiana. We want to externally verify our data with another project set up to detect cosmic rays. We also want to compare data that was collected on two different boards. This will allow us to use two different DAQ boards and compare the data as though they were on the same board. Methods: To coordinate with GRAND, we compared the raw flux rate for a thirty-minute sample. Once we had the raw rates, we had to scale the rates based on the surface area of the detectors. We also had to take into account the solid angle at which a given muon could strike the detectors and cause a coincidence amongst the detectors. Once we had taken into account these factors, we could compare our rates. For comparing two boards we created an excel program. First, we have a program that skims the data and consolidates extraneous bits of data to make analysis easier. Then we used the Excel program to match the data from both boards. These matches told us when a shower of muons had hit our detectors. Results: In our collaboration with GRAND, we found that our muon flux rates were not the same. Ours were higher. With some investigation we found that on GRAND's system, there is a five-millisecond reset time after each muon count. In those five milliseconds, potential muons might be missed. The Excel program to compare the two boards worked (after many failures) very well. We verified its success by matching its outputs with the outputs of the Cosmic Ray e-Lab. Further work: There are still many things that can be compared to Project GRAND. Now that we have a program to compare two DAQ boards, we can increase our detectors from four maximum to eight maximum.

Project GRAND

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Purpose: To collect muon flux data that helps us understand cosmic rays and what is occurring on the sun. Methods: Use proportional wire chambers to count the number of muons entering an area and to see shower effects. Results: Ongoing study. Meaning to larger project: To keep collecting data on cosmic rays and to be able to compare this data to past data. Further work: To continue collecting data so as to continue studying cosmic rays.

LHC Modeling in the DVT

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Our primary goal in the DVT group was to update and create new computer models to be used in the Digital Visualization Theater in the Jordan Hall of Science. Although the DVT is primarily used as a digital planetarium, we have been creating models of detectors at the LHC at CERN to be used by undergraduate and graduate students at the University of Notre Dame. The first week of the program was spent at a workshop in Jordan Hall where we learned how to use all of the tools in LightWave, the program used to construct the models. After the workshop, we continued to construct models of both LHC detectors as well as size comparison objects, such as the Sears Tower, an aircraft carrier, an X-wing fighter, the Starship Enterprise, and a fighter jet. We wanted to incorporate a few comparison objects so that the students utilizing the models would have a good idea of the size of the LHC detectors. In order to project our models in the DVT, we had to use a program called NuGraf to convert our models into DirectX files that are compatible with the program DigitalSky that is used in the DVT. We had to work out numerous technical difficulties, from faulty textures to incorrect sizing, so that the models would project correctly in the DVT. We also used a program called Partiview, where we simulated particle collisions using animations. Using data from the CMS detector at CERN, we were able to simulate an actual Higgs event as well. By the end of the summer, we took a LightWave modeling workshop, improved upon existing LHC models, constructed new detectors and improved/constructed various comparison objects. We also got to know different types of software and learned how to fix technical problems with our models.

Biocomplexity

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In biocomplexity, computer models are created and used to simulate natural systems that allow simple observations to be made about how these natural systems work. To make these simulations, a program called NetLogo was used. NetLogo is a free programmable environment using a turtle-based system that allows the user to direct the turtles through the program that was written. The purpose of the research was to advance the simulation capabilities of the simple cellular automata program, the Game of Life, by adjusting the rules of the original cellular life in order to allow the cells to mutate into a new type of cell within the game that follows new rules. Also, it was to create a flocking simulation that includes a predator in order to create a predation model. This was done using the program NetLogo and its preloaded simulations. One was the Game of Life based off of John Conway's original rules. Using this program, a mutation feature was added into the code allowing the "cells" to change color and follow a different set of rules after a given amount of time that they have not changed states from dead to alive. Resulting from this change, the new formations continually evolve and the more favorable rules of the patches survive. The other simulation was based off of a flocking simulation. The alteration consisted of creating predators that pursued the prey and prey that fled from an incoming predator. Also, a flocking feature for the predators was added, which allowed for hunting in packs. This project affects the entire QuarkNet program because it will continue to extend the educational opportunities of students for research. Finally, to extend the application of this project, the next step would be to search for biological systems that follow this pattern, and to look to improve the simulation of these real biological systems.

CMS Upgrade

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In February 2013, the CMS detector at CERN will undergo an upgrade for more effective equipment. The goal of this is to improve the signal quality of the CMS detector with optical mixers and waveshifting fiber optics. By using optical mixers, the hope is to get more accurate photon counts by taking light from a source and evenly distribute it across a photosensor in order to prevent the input signal from saturating any portion of the sensor while overcoming noise. In addition, the material used for the mixers had to be reasonably radiation hard to withstand the conditions in the detector. Large diameter, plastic fiber optic cables were tested on their light transmission and optical profile. Each mixer was placed in front of a photodiode to measure light transmission and then in front of a CCD camera to examine its optical profile. Various techniques of making the optical mixers, including fly cutting, freehand razor cutting the optical fibers and changing the positions of the mixers, were tested. It has been discovered that razor cutting the optical fibers and tightly binding them between the sensor and source yielded a >90% transmission and significant mixing, which is on par with an optical fiber that has been precision cut. The purpose of having the waveshifting fiber inserted into the quartz capillary tube was to take the blue light from the scintillating panels, waveshift it to green, and then let it propagate to the sensor. Similar to the optical mixers, the quartz capillary tube was profiled and tested for transmission. The tests have revealed that the quartz capillary tube works as a partial mixer but its transmission capabilities suffer significant attenuation. This may affect the viability of using it in the CMS detector.